Anita

Georgia Department of Natural Resources

205 Butler Street, S.E., Suite 1154, Atlanta, Georgia 30334
Lonice C. Barrett, Commissioner
Environmental Protection Division
Harold F. Reheis, Director
404/656-2833

Certified Mail
Return Receipt requested

November 27, 2002

Copy

Mr. Richard C Atwood
General Manager
PCS Nitrogen Fertilizer, L.P
P.O. Box 1483
Augusta, Georgia 30903

RE: Response to Comments, PCS Nitrogen Fertilizer, L.P., Augusta, GA USA, GAD057281958.

Dear Mr. Atwood:

We have reviewed your response to comments dated August 1, 2002 and have the following response:

In that letter you state that PCS Nitrogen *"has no responsibility for remediation of any plume that originated from an offsite source*. The Consent Order (Order No. EPD-HW 1251) executed between PCS Nitrogen and EPD specifically requires that PCS Nitrogen remediate all constituents of concern on PCS property to acceptable levels and does not exclude constituents that allegedly came from off site. The only exception would be releases coming from SWMU 42 (Intermediate product Storage Tank (Cyclohexanone/ Cyclohexanol). The history of operation on the combined former DSM/ PCS site makes it clear that ground water contamination (including benzene) was already present on your property when you acquired it from DSM. PCS therefore acquired any contaminated ground water with the property purchase and therefore is responsible for its cleanup.

In view of the above, please submit an amended Corrective Action Plan (CAP) for all constituents of concern. The CAP also needs to include installation of hydraulic controls such as interceptor wells to prevent the uncontrolled migration of constituents mobilized by the injection system. We feel this safety precaution is necessary to protect the drinking water aquifer. We have no problem with PCS Nitrogen preparing a Risk Assessment (RA) prior to submitting an amended CAP. It is recommended that you consult with Mr. Jim Brown of our Risk Assessment Unit prior to preparing the RA. Enclosed is a copy of our RA Guidance document.

Finally, in your August 21 letter you indicated you could submit a Risk Assessment within 45 days. This is acceptable. An extension can be granted if necessary. We would be looking for an amended CAP approximately 60 days after our approval of the Risk Assessment. We would be happy to meet to discuss these issues, if desired. If there are any questions please contact Bob Pierce at 404-656-2833.

Sincerely.

Jim Ussery, PE
Program Manager
Hazardous Waste Management Branch

cc: Region IV –USEPA

R418741

PCS Nitrogen AUGUSTA

PCS NITROGEN FERTILIZER, L.P. P.O. BOX 1483, AUGUSTA, GA USA 30903
PHONE: (706) 849-6100 FAX: (706) 849-6111

David Yardumian
Unit Coordinator
Hazardous Waste Unit
Environmental Protection Division
Georgia Department of Natural Resources
205 Butler Street, S.E., Suite 1162
Atlanta, Georgia 30334

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OCT 2 9 2001
HAZARDOUS ... BRANCH

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RECEIVED

Re: Corrective Action Order
No. EPD-HW-1251
Corrective Action Plan

Dear Mr. Yardumian:

Please find enclosed four copies of the PCS Nitrogen Fertilizer, L.P., Augusta, Georgia Plant's (PCS) Corrective Action Plan (CAP) as required to be submitted by Corrective Action Order No. EPD-HW-1251. The Consent Order also requires a demonstration of financial responsibility for completing such corrective action as required by 40 Code of Federal Regulations (CFR) Section 264.101(b). This will be submitted to EPD in the near future---PCS does not foresee any problems with making the financial demonstration, but all the materials required for the demonstration were not gathered by this date.

As contemplated by the Consent Order and RFI process, the CAP only addresses one plume for trichloroethylene originating from push well P; the other plumes are being addressed by DSM pursuant to separate independent arrangements with EPD. It is our understanding that PCS has no responsibility for clean up of the other trichloroethylene plumes. If our understanding is incorrect, please notify us. Also, we will endeavor and ask EPD, to coordinate activities of PCS and others at the site to ensure effective implementation of remedial action.

I certify under penalty of law that this CAP and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

R4180614

If you have any questions with regards to this submittal, please contact John Hewson of my staff at (706) 849-6229.

Sincerely,

Richard C. Atwood

Richard C. Atwood
Plant Manager

Anita

Georgia Department of Natural Resources

205 Butler Street, S.E., Suite 1154 Atlanta, Georgia 30334
Lonice C. Barrett, Commissioner
Environmental Protection Division
Harold F. Reheis, Director
Phone: 404-656-2833 Fax: 404-651-9425

2003 JAN 23 A 10: 30

January 6, 2003

Certified Mail
Return Receipt Requested

Mr. John Hewson
PCS Nitrogen Fertilizer, L.P.
P.O. Box 1483
Augusta, Georgia 30903

RE: Risk Assessment Workplan
Extension Request Approval
CA Order No. EPD-HW-1251
EPA ID No. GAD 057 281 958

Dear Mr. Hewson:

The Georgia Environmental Protection Division has reviewed PCS Nitrogen's request for an extension to the submittal of the Risk Assessment Workplan. The proposed schedule, with an April 14, 2003 submittal date, is acceptable to EPD and is hereby approved.

If you have any questions about the new submittal date please contact Bob Pierce or Ken Grall at 404-656-2833. If you have any questions about how the Risk Assessment Workplan should be prepared please contact Jim Brown, Risk Assessment Unit Coordinator, at 404-656-7802.

Sincerely,

Dave Yardumian

Dave Yardumian
Unit Coordinator

DY:kg
File: PCS Nitrogen (R)
cc: Doug McCurry - EPA Region IV ✓
S:\RDRIVE\KENG\PCS\RA WP Extension.doc

R4177632

Georgia Department of Natural Resources
205 Butler Street, S.E., Suite 1154 Atlanta, Georgia 30334
Lonice C. Barrett, Commissioner
Environmental Protection Division
Harold F. Reheis, Director
Phone: 404-656-2833 Fax: 404-651-9425

October 10, 2001

Certified Mail
Return Receipt Requested

Arcadia Fertilizer Vanaspur

Mr. Virgil Fowler
S.H.E. Manager
PCS Nitrogen Fertilizer, L.P.
P.O. Box 1483
Augusta, Georgia 30903

RE: Corrective Action Plan
CA Order No. EPD-HW-1251
EPA ID No. GAD 057 281 958

Dear Mr. Fowler:

The Georgia Environmental Protection Division (EPD) received a draft corrective action plan from PCS Nitrogen Fertilizer, L.P. (PCS) on October 9, 2001. The plan has not been reviewed and is enclosed for return to PCS. Reasons for the return are the plan is a draft, the plan has not been signed, dated nor stamped by a professional geologist or engineer registered in the State of Georgia, the plan does not include a demonstration of financial responsibility in accordance to Condition II.F.3 of Corrective Action Order No. EPD-HW-1251, and the plan does not include a schedule of implementation in accordance to Condition II.F.2 of Corrective Action Order No. EPD-HW-1251. In addition a corporate officer should certify the plan in accordance to the following wording:

"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision according to a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations."

Within fifteen (15) days of your receipt of this letter please resubmit four (4) copies of the required corrective action plan. If you have any questions please contact Bob Pierce or Ken Grall at 404-656-2833.

Sincerely,

Dave Yardumian

Dave Yardumian
Unit Coordinator

DY:kg
File: PCS Nitrogen (R)
cc: Doug McCurry - EPA Region IV
S:\RDRIVE\KENG\PCS\CAP Return.doc

R 4180616

Georgia Department of Natural Resources
2 Martin Luther King Jr. Dr., S.E., Suite 1154 Atlanta, Georgia 30334
Lonice C. Barrett, Commissioner
Environmental Protection Division
Dr. Carol C. Couch, Director
Phone: 404-656-2833 Fax: 404-651-9425

December 18, 2003

Certified Mail
Return Receipt Requested

Mr. Virgil Fowler
Safety, Health, Environmental Manager
PCS Nitrogen Fertilizer, L.P.
P.O. Box 1483
Augusta, Georgia 30903

RE: Notice of Deficiency #2
Risk Assessment Workplan
- dated August 2003
CA Order No. EPD-HW-1251
EPA ID No. GAD 057 281 958

Dear Mr. Fowler:

The Georgia Environmental Protection Division (EPD) has reviewed PCS Nitrogen's Risk Assessment Workplan dated August 2003 and has found the plan deficient. Please review the following comments for incorporation into a revised workplan. These comments refer to EPD's comments based on the original Workplan and comments on the new Revised Workplan dated August 2003.

1) The original EPD Comment No. 1 requested that the conceptual site model be modified to reflect the recommended exposure pathways for soil screening exposure scenarios included in Exhibit 3-1 (SSG). This comment has not been adequately addressed in the revised workplan. Specifically, the following applicable pathways from the SSG have not been addressed in the text and/or added to the Conceptual Site Model in Figure 1 of the Work Plan.

Receptor	Recommended Exposure Pathways
Construction/Utility Worker	inhalation of volatiles from subsurface soil
	inhalation of fugitive dust outdoors from surface soil
Industrial Worker	direct ingestion & dermal absorption of surface and subsurface soil[1]
	direct ingestion of groundwater

[1] Since the industrial worker functions as an outdoor worker (Section 4.2.4.2.3 of the workplan), these exposure pathways are recommended in Exhibit 3-1 (SSG)

Please add these pathways to the Conceptual Site Model in the Workplan.

2) The original EPD Comment No. 3 requested that the potential risk from the direct ingestion of the shallow groundwater be evaluated and presented in the discussion. This comment has not been addressed in the revised workplan. The state of Georgia requires that all groundwater be viewed as a potential source of drinking water. The fact that the groundwater (in all aquifers) is not currently being used as a drinking water source allows us to exclude groundwater consumption in the current exposure scenarios. However the risk assessment should include reasonable future use scenarios and the groundwater must ultimately be remediated to drinking water standards. The fact that the groundwater concentrations are 300 to 400 times greater than the MCL for 1,1-dichloroethylene and trichloroethylene, respectively, does cause some urgency, as the longer the plumes are allowed to exist, the larger the likelihood that harm to human health and the environment may occur. This pathway must be added to the risk assessment.

3) The original EPD Comment No. 4 concerning receptors requested justification for the omission of a trespasser receptor. After further consideration and discussion with the compliance officer, it has been decided that the highly industrialized nature of the facility will result in the trespasser receptor likely having insignificant exposure in comparison to the other receptors, and, thus, may be excluded.

4) The original EPD Comment No. 5 instructed that for the exposure scenarios exposed to subsurface soil other than the construction worker, the residential PRGs must be used. Presumably, since this revision of the workplan did not include exposure of the industrial worker to subsurface soil, addressing this comment was not deemed necessary by the facility. However, when the exposure pathways are modified according to Comment 1 of this memo, the screening of subsurface soils for the industrial worker should be performed using the residential PRG values.

5) The original EPD Comment No. 8 has not been adequately addressed in the revised workplan. Section 4.2.1 of the Workplan still indicates that the deep surficial aquifer and the Basal Cretaceous aquifer will not be evaluated in the risk assessment. The state of Georgia requires that all groundwater be viewed as a potential source of drinking water. The fact that the groundwater (in all aquifers) is not currently being used as a drinking water source allows us to exclude groundwater consumption in the current exposure scenarios. However the risk assessment must include reasonable future use scenarios and the groundwater must ultimately be remediated to drinking water standards, if those standards are not currently met.

6) Upon review of the revised workplan the following supplemental comments have been generated.

a.) Justification for excluding future residential receptors should be substantiated by information about the area, such as zoning laws, local city planning projections, etc., if available.

b.) EPD is not convinced that Industrial Site Workers are only exposed to outdoors for 4 hours a day as indicated in Table 3. The nature of the chemical plant would seem to indicate that workers would frequently have to spend full days performing outdoor work such as modifying and repairing chemical process units. Buildings that are essentially open to outdoor air and without filtered air conditioning units should also be considered as having outdoor air exposure. An exposure time (ET) of 8 hrs/day would be more appropriate for the Industrial Site Worker.

c.) Section 5, Ecological Risk Assessment, states there is virtually no habitat for ecological receptors and therefore no complete exposure pathways at the site thus leading to PCS's conclusion no further evaluation of ecological risks is warranted. EPD disagrees with this conclusion. Many ecological receptors surround the PCS site. The groundwater at the site historical has been shown to fluctuate in elevation and flow direction. These sites could potentially be impacted by migration of contaminated groundwater and must be protected. In order to continue with the pursuit of a risk assessment PCS must include an ecological evaluation in the risk assessment that ensures the environment will be protected. For reference PCS should review Section 4.0, Screening Level Ecological Risk Assessment, in DSM's <u>Revised Central Production Area Risk Assessment</u>.

REFERENCES

(R4B) EPA Region 4 Human Health Risk Assessment Bulletins – Supplement to RAGS (EPA, May 30, 2000)

(SSG) United States Environmental Protection Agency, Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites (OSWER 9355.4-24, March 2001)

A revised Risk Assessment Workplan is due within thirty (30) days of your receipt of this letter. If you have any questions regarding the aforementioned comments please contact Ms. Tonia Burk of the Risk Assessment Unit at 404-656-7802.

Sincerely,

Dave Yardumian

Dave Yardumian
Unit Coordinator

DY:kg
File: PCS Nitrogen (R)
cc: Doug McCurry - EPA Region IV
S:\RDRIVE\KENG\PCS\RA WP NOD #2.doc

Corrective Action Plan

PCS Nitrogen Fertilizer, L.P.
Augusta, Georgia
EPA ID No. GAD057281958

OCT 2 9

ARCADIS

October 2001

PREPARED FOR

PCS Fertilizer, L.P.
23 Columbia Nitrogen Road
Augusta, Georgia 30901

RA 180615

ARCADIS

Corrective Action Plan

PCS Nitrogen Fertilizer, L.P.
Augusta, Georgia
EPA ID No. GAD057281958

Joseph F. Darby
Project Engineer

Evan B. Clark, P.E.
Environmental Business Practice
Manager, Atlanta

Pedro Fierro, Jr., P.G.
Associate

Prepared for:
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Augusta
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Prepared by:
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3903 Northdale Boulevard
Suite 120
Tampa
Florida 33624
Tel 813 961 1921
Fax 813 961 2599

Our Ref.:
TF000964.0006

Date:
October 2001

Statement of Engineering Review

In accordance with Section 391-3-11 of the Georgia Rules for Hazardous Site Response (HSRA Rules), this Corrective Action Plan for PCS Nitrogen Fertilizer, L.P. located in Augusta, Georgia has been reviewed, signed, and sealed by a registered Professional Engineer in the State of Georgia, and is consistent with standard engineering principles related to groundwater remediation systems.

I certify that I am a qualified groundwater scientist who has received a baccalaureate or postgraduate degree in natural science or engineering, and have sufficient training and experience in groundwater hydrology and related fields, as demonstrated by state registration and completion of accredited university courses, that enable me to make sound professional judgments regarding groundwater monitoring and contaminant fate and transport. I further certify that this report was prepared by myself or by a subordinate working under my direction.

Evan B. Clark, PE
State of Georgia License No. 23871

Date: 10/22/07

GEORGIA REGISTERED No. 23871 PROFESSIONAL ENGINEER EVAN B. CLARK

ARCADIS

Table of Contents

Tables

Figures

Appendices

1. Introduction

This Corrective Action Plan (CAP) has been developed for the PCS Nitrogen Fertilizer, L.P. (PCS Nitrogen) Augusta, Georgia facility. This CAP has been prepared to fulfill the requirements of the Corrective Action Order Number EPD-HW-1251, and will be implemented in accordance with that order.

The RCRA Facility Investigation (RFI) was approved by the Georgia Environmental Protection Division (EPD) on July 20, 2001 (letter attached in Appendix A). This letter requested preparation of the CAP per the Corrective Action Order. The following sections include a description of the site background, summary of the Corrective Action Order activities, and description of the contamination.

1.1 Site Background

The PCS Nitrogen facility (EPA ID No. GAD 057281958) is located approximately two miles southeast of downtown Augusta, Georgia near the Savannah River as shown on the site location map, Figure 1. PCS Nitrogen is a fertilizer manufacturer that produces ammonia, nitric acid, urea, and ammonium nitrate for industrial and agricultural applications.

The PCS Nitrogen facility, formerly Arcadian, was leased from the adjacent industrial facility owned by DSM Chemicals, N.A., Inc (DSM Chemicals). In the mid 1990's PCS Nitrogen purchased the leased property from DSM Chemicals. As shown on Figure 1, the DSM Chemical facility surrounds the PCS Nitrogen site on the east, west, and south sides. The DSM Chemical facility manufactures synthetic organic chemicals and is the largest independent supplier of caprolactum, a monomer of nylon used in nylon production, in the United States, and the second largest producer of caprolactum in the world. Other products manufactured at the DSM Chemicals facility include ammonia sulfate and cyclohexanone.

1.2 Summary of Corrective Action Order Activities

During April, June, and September 1993, Georgia EPD performed a RCRA Facility Assessment (RFA) inspection of the DSM Chemicals facility, which at the time, included land leased to Arcadian, currently PCS Nitrogen. The results of the RFA inspections were provided in the RFA report (GA EPD, 1994). The RFA identified several Solid Waste Management Units (SWMUs) requiring further investigation.

On March 21, 1994, DSM Chemicals provided notification to Georgia EPD of ten releases at the PCS Nitrogen site in accordance with Georgia Hazardous Site Response Act (HSRA) requirements. Three of the ten releases had occurred on the property leased to Arcadian by DSM Chemicals. The ten locations were classified as SWMUs by the Georgia EPD in the RFA.

On October 9, 1996, a Corrective Action Order EPD-HW-1251 was executed between Georgia EPD and Arcadian Fertilizer, L.P. This order included the initiation of Interim Measures (if needed), performance of a RCRA Facility Investigation (RFI), and Corrective Action for the ten SWMUs identified in the Corrective Action Order including SWMUs 42, 43, 44, 45, 46, 47, 48, 49, 50, and 51. Of these SWMUs, SWMU 43 was identified in the Corrective Action Order as requiring no further action. Also, SWMU 42 was to be investigated by DSM Chemicals. Thereby, leaving eight SWMUs to be investigated by PCS Nitrogen.

In February 1998, ARCADIS G&M, on behalf of PCS Nitrogen, submitted the first RFI report (ARCADIS February,1998) that included an investigation of the eight remaining SWMUs on the PCS Nitrogen site. The findings of the report are as follows:

- A release assessment was completed for SWMUs 44, 49, 50, and 51, and the findings for each of these areas was that there were low levels of constituents detected and no further action was recommended.

- SWMUs 45, 46, 47, and 48 were grouped into one Solid Waste Management Area (SWMA) due to their close proximity; this area is referred to as SWMA A. Depressed pH values were observed in the groundwater in this area.

In April 1998, Georgia EPD requested that a Phase II RFI work plan be submitted to investigate the groundwater plume in the area of SWMA A. Also, volatile organic compound (VOC) analysis was required for groundwater samples from wells ARC-U2D and ARC-U3D.

In November 1998, ARCADIS G&M, on behalf of PCS Nitrogen, submitted the Phase II RFI report (ARCADIS November 1998). The work included 10 direct push boring locations for pH measurements and sampling of the two wells mentioned above for VOCs. The pH data indicated varying pH measurements ranging from 3.9 to 7.3. The groundwater analysis at ARC-U2D indicated low levels of 1,1-dichloroethene that

slightly exceeded Environmental Protection Agency (EPA) maximum contaminant levels (MCLs).

In December 1998, Georgia EPD requested a Phase III RFI to delineate the VOCs that were detected at well ARC-U2D.

In September 2000, ARCADIS G&M, on behalf of PCS Nitrogen, submitted the Phase III RFI Report Addendum (ARCADIS 2000). The work included a records search, installation of 46 direct push monitor wells to delineate vertical and horizontal extent of VOCs in the shallow and deep surficial aquifer, collection of groundwater samples from the 46 direct push monitor wells and four existing monitor wells, and measurement of groundwater levels. The major findings in this report are summarized as follows:

- Three VOC plumes were discovered in the investigation. One on the PCS Nitrogen property near direct push monitor well P and two plumes on the DSM Chemical Property in the vicinity of former shallow aquifer monitor well MW-3 and the other near the Central Shops tank (DSM Chemical SWMU 52). The two plumes observed on the DSM Chemical property may be one plume or co-mingled plumes, the data was inconclusive.

- The VOC compounds observed at the PCS Nitrogen plume (near direct push well P), included trichloroethylene (TCE), 1,1-dichloroethylene, cis-1,2-dichloroethylene, vinyl chloride, 1,1-dichloroethane, and 1,1,2-trichloroethane.

- The plume on the PCS Nitrogen property appears to originate from direct push well P and extends 800 feet to the east and 1,200 feet to the west with a maximum width of 1,100 feet in the north-south orientation.

- A records search of TCE indicated that TCE is not manufactured at the PCS Nitrogen facility nor is TCE used in the formulation of its fertilizer products. A former employee had recalled using TCE solvent to clean an exchanger in the area of direct push monitor well P. No spills or incidental releases were observed during the cleaning operation.

On July 20, 2001, the Georgia EPD issued a letter accepting the Phase III RFI Report Addendum and also requesting submittal of the Corrective Action Plan. This letter is provided in Appendix A.

1.3 Description of the Contamination from a Remediation Perspective

The area of contamination includes a groundwater plume that is suspected to originate from an area near direct push well P; however, the exact nature and timing of the TCE release is unknown. In this general location, chlorinated VOCs (predominantly TCE), are present in the shallow surficial aquifer and extend down to the deep surficial aquifer.

Generally across the site, the top of the surficial aquifer is 6-10 feet below land surface. A cross section of the geology of the surficial aquifer is shown in Figure 2. This profile is generally north to south across the PCS Nitrogen site starting south of the rail road tracks (profile location is shown on Figure 3). The general lithology of the plume area is expected to be similar to the lithology of monitor well ARC-U1D, which is approximately 450 feet southwest of the suspected source area. Generally, the geology in this area appears to be a clayey silt zone extending from the surface down to 18 feet below land surface (bls); this zone is considered to be the shallow surficial aquifer. Below this layer is a fine to coarse sand layer extending from 18 feet bls to 38 feet bls; this zone is considered to be the deep surficial aquifer. Below the sand layer, a clayey silt layer is present. This clay layer is assumed to be fairly competent and is interpreted to be the lower confining unit of the surficial aquifer. The investigation did not extend down into this layer.

During the RFI Phase III field work, forty six direct push wells were installed within the shallow and deep surficial aquifers to delineate the TCE plume. The TCE plume map showing the 5 ug/L and 100 ug/L iso-concentration lines in the shallow surficial aquifer is shown in Figure 3 and the deep surficial aquifer in Figure 4. From these iso-concentration diagrams, the pattern of the TCE movement appears to be typical of other TCE release sites. It appears that the release was in the area of direct push well P and migrated vertically due to its high density. The vertical migration continued down through the more permeable sand layer to the lower clay unit where further vertical migration was hindered. Once the TCE reached the permeable sand layer (deep surficial aquifer), the TCE moved horizontally with the groundwater. This pattern is evident in the data; however, the horizontal TCE movement in the deep surfical (sand) zone appears to move in multiple directions. From the source area, the plume extends predominately to the west-southwest, but also appears to move south and east.

The potentiometric surface of the deep surficial aquifer during the Phase III RFI work (Figure 5) indicated that there was a groundwater high on the western half of the PCS Nitrogen property and the groundwater flow direction was to the northeast, southeast,

and south. In addition, groundwater flow direction may reverse due to fluctuations in the nearby Savannah River. These reasons may explain why the plume appears to be moving in multiple directions.

It is hypothesized that TCE is adsorbed to clayey silt soils in the vadose and saturated zones in the suspected source area. TCE from this area may slowly desorb over time, which in affect, will act like a continuing source of TCE to the underlying deep surficial aquifer. It is recommended that active remediation be completed in this area. Also, it appears, as shown on Figure 4, that the southwest tip of the TCE plume has crossed the PCS Nitrogen property boundary onto the DSM Chemical property. This area is also recommended for active remediation.

2. Corrective Action Goals

The groundwater quality criteria used in the RFI was the EPA MCLs. These values will also be used for evaluation in this report. PCS Nitrogen reserves the right to perform a site assessment and establish site specific groundwater clean-up levels at a later date. Since the PCS Nitrogen site and adjacent DSM Chemical site are industrial sites, higher concentration clean-up standards may be applicable based on the site assessment calculations.

In Table 1, the detections of VOC compounds within the PCS plume are shown. This table and the data collected in the Phase III RFI work included ten chemicals of concern (COCs) for the site. Of these ten compounds, benzene, total xylenes, and 1,1,2-trichloroethane, will be eliminated from the future COC list because there were no detections in the PCS Nitrogen plume. The list of COCs for the CAP activities and the MCLs are listed below.

Trichloroethylene (TCE)	5 micrograms per liter (ug/L)
1,1,1-trichloroethane	200 ug/L
Cis-1,2-dichloroethene	70 ug/L
Vinyl Chloride	2 ug/L
1,1-dichloroethene	7 ug/L
1,1-dichloroethane	none
Chloroform	80 ug/L

3. Evaluation of Remedial Alternatives

ARCADIS G&M performed an evaluation of traditional and innovative remedial alternatives to address the TCE groundwater plume. To determine the most appropriate

remedial strategy for this site, several technologies were considered and evaluated using the following criteria:

- long- and short-term environmental effects
- whether the remedial alternative can achieve the cleanup objectives
- whether the remedial alternative will reduce the mobility and toxicity of the impacted media
- whether the remedial alternative is feasible, reliable, and readily implementable
- the anticipated time frames to achieve cleanup objectives
- whether the capital and operation and maintenance (O&M) requirements and costs associated with the remedial alternative are reasonable
- whether there are potential legal or access barriers to implementation

ARCADIS G&M also considered the following factors during the remedial alternatives evaluation:

- type/concentration of COCs present in groundwater
- extent of plume migration
- site geology/hydrogeology
- the presence of naturally occurring biological degradation processes
- localized land features, such as use, surface water bodies or lack thereof, etc.
- impact to activities at the PCS Nitrogen facility and affected adjacent properties.

The following sections describe the alternatives evaluated and present the basis for selection of the preferred alternative.

3.1 Alternatives Screening

The remedial technologies considered for groundwater remediation are as follows: 1) no action, 2) air sparging, 3) *in situ* oxidation, 4) groundwater pump and treat, 5) *in situ* reactive zone and 6) monitored natural attenuation. The following subsections describe the benefits and limitations associated with each of these remedial alternatives as they relate to specific conditions at the PCS Nitrogen site.

3.1.1 No Action

PCS Nitrogen is currently under an Administrative Consent Order to provide corrective measures for the plume identified in the RFI work. Concentrations of chlorinated solvents are in excess of EPA MCLs. Also, with no action, concentrations for certain compounds, most notably TCE, are likely to exceed site specific groundwater clean-up standards for industrial areas. Therefore, the no action alternative was eliminated from consideration.

3.1.2 Air Sparging

Air sparging involves injection of ambient air into sparge points located within the TCE impacted area, thereby promoting *in situ* volatilization of VOCs. The TCE containing vapors would rise to the surface of the aquifer, through the vadose zone, and to the atmosphere. This vapor release from the vadose zone to the atmosphere can occur naturally or with the help of a vacuum extraction system.

For the PCS Nitrogen site, air sparge wells can be installed and the TCE can be volatilized *in situ*; however, the upward movement of the TCE vapors will be severely hindered because of the clayey silt zone of the shallow surficial aquifer. This clayey silt zone extends from land surface to a depth of approximately 18 feet bls (groundwater depth is 6-10 feet bls). Capture of the TCE vapors, even with a soil vacuum system, will be unlikely. Vapor migration along the upper clayey silt zone is possible. As a result, air sparging may even spread the plume under these geologic conditions. Given this, air sparging is not recommended for the site.

3.1.3 In Situ Oxidation

In situ oxidation involves the injection of an oxidizer into the impacted aquifer to oxidize the chlorinated VOCs. Fenton's reagent, which is the use of hydrogen peroxide with an iron catalyst, has been used to oxidize high concentrations of

chlorinated VOCs, and the technology has obtained approval from the Georgia Underground Injection Control Coordinator. However, approval of its use is on a site-by-site basis. Other oxidizers are also available, such as pure oxygen, hydrogen peroxide alone, and potassium permanganate. All of these oxidants are nonspecific and will oxidize any material present in the subsurface that is capable of being oxidized.

For this technology to be cost effective, the aquifer generally needs to be a clean sand and/or gravel. This is necessary so that oxidants can be effectively dispersed throughout the aquifer and so large amounts of oxidants are not consumed on non-target material including naturally occurring organic carbon. While the deep surficial aquifer is made up of sand at the PCS Nitrogen site, the source area is predominantly clayey silt matrix. In-situ oxidation will be less effective in this area and the source area could act as a continuing source of chlorinated VOCs to the deep surficial aquifer.

Even though this technology may be effective in oxidizing chlorinated VOCs in the immediate area of an injection well in the sandy part of the aquifer, it will also kill the microorganisms that are currently active at the site and will create an environment that is not conducive to the reductive chlorination (reductive chlorination is evident because of the presence of breakdown products across the plume).

Because of the disruption or elimination of natural reductive chlorination processes and the inability to thoroughly treat the source area, in-situ oxidation was eliminated from further consideration.

3.1.4 Groundwater Pump and Treat

The general term "pump and treat" applies to any form of groundwater recovery and aboveground treatment system (e.g., air stripping, carbon adsorption), with treated water disposal via various options (e.g., local sewer system, National Pollutant Discharge Elimination System [NPDES] permitted outfall, reinjection, or infiltration).

Several pump and treat options exist at the site, including source area pumping, entire plume pumping, and containment pumping. Pumping at the source area only may be able to reduce the mass in those areas. Pumping throughout the plume is possible, but may require treatment and discharge of significant volumes of water.

Historical data and experience indicate that pump and treat systems, as a primary clean-up technology for chlorinated VOCs, are not effective in achieving site closure in

a timely manner. However, when used in conjunction with other treatment technologies, limited pump and treat systems can decrease the treatment time by facilitating the movement of injection solutions.

The Phase III RFI work detected three plumes that appear to result from industrial solvent releases; one on the PCS Nitrogen property and two on the DSM Chemicals property. The two plumes on the DSM Chemical property may actually be one larger co-mingled plume in the area of the Central Shops. This DSM Chemical plume is adjacent to PCS Nitrogen and actually extends onto the PCS Nitrogen property. It is possible that if active groundwater pumping is used as a remediation method for the PCS Nitrogen plume, the DSM Chemical plume(s) may be pulled further onto the PCS Nitrogen property.

Due to the unlikely chance of success in achieving site clean-up goals and the potential to move the DSM Chemicals plume(s) further onto the PCS Nitrogen site, the application of pump and treat technology was eliminated from further consideration.

3.1.5 *In Situ* Reactive Zone (IRZ™)

In situ reactive zone (IRZ™)is a patented technology that involves the injection of a carbon source into the TCE impacted zones of the aquifer. The carbon source acts as a food source for naturally occurring microorganisms. The additional food source increases the population of the microorganisms and the oxidation/reduction potential is decreased and a reducing environment is formed. Within this environment, naturally occurring bacteria transform chlorinated VOCs through the process of reductive chlorination by stripping the chlorine molecules from the chlorinated VOCs as shown below.

Trichloroethene

↓ Reductive Dechlorination

1,2-Dichloroethene

↓ Reductive Dechlorination

Vinyl Chloride

$\downarrow$ Reductive Dechlorination

Ethene

Over time breakdown products of TCE will be formed, and eventually these compounds will be broken down into carbon dioxide, water, and chlorides. This process can occur naturally; however, the process can be accelerated by the injection of a carbon source.

The IRZ™ system enhances natural subsurface processes at the site via injection of a readily degradable, non-toxic carbon source (diluted molasses solution), to enhance the anaerobic and reductive environment and promote degradation of organic compounds. The continued application of the carbon source over time will stimulate development of microbial populations, maintain a reducing environment, and promote biodegradation of the chlorinated VOCs in localized areas. The major advantage of this technology is that the VOCs are destroyed *in situ* without removing groundwater from the aquifer or causing contaminants to change phase.

ARCADIS G&M's experience with this particular technology indicates that it is reliable and readily implemented. The capital costs to implement this alternative would include installation of additional injection wells and periodic injection of a molasses solution. The operation and maintenance (O&M) requirements would include supplemental additions of the carbon source and monitoring of groundwater quality. Both the capital and O&M requirements and costs are reasonable to accelerate the natural processes to potentially achieve the cleanup objectives within five years.

3.1.6 Monitored Natural Attenuation

It is well documented that chlorinated VOCs, including TCE, can naturally degrade in an anaerobic and reducing environment. This degradation occurs via the process of dehalogenation, or reductive dechlorination, as discussed in the previous section. Monitored natural attenuation (MNA) has increasingly become a recognized and viable alternative for mitigating chlorinated VOCs in groundwater.

Table 1 presents the chlorinated VOC detections in the plume and identifies the breakdown products of commonly used solvents TCE and 1,1,1-trichloroethane. As shown, breakdown products are most notably present at the well locations with higher TCE concentrations. This is a very first strong indicator that reductive de-chlorination is occurring. The most compelling evidence that TCE is breaking down naturally, is to observe the trends in TCE and breakdown products over time. To date, there is only one set of data that shows the VOC concentrations across the plume and this evaluation can not be performed. Additional data over time can be evaluated to assess the occurrence and rate of natural attenuation.

The MNA alternative requires the least capital outlay and results in ultimate destruction of the chlorinated VOCs. Another significant advantage to this alternative, is that groundwater extraction is not required. As mentioned previously, groundwater pumping may pull the DSM Chemical property plume(s) further onto the PCS Nitrogen property.

The disadvantage with this method is that it can be very slow and the duration to achieve groundwater rehabilitation completion may be excessive. Currently, data does not exist to estimate the remediation time period using a monitored and natural attenuation approach.

3.2 Selected Remedial Alternative

The no action, air sparging, *in situ* oxidation, and groundwater pump and treat alternatives were eliminated from further consideration based on the preliminary screening evaluation, for reasons discussed above.

The IRZ technology appears to be a cost effective and under these circumstances the best remediation technique for the site because it appears that natural biodegradation of TCE is occurring. Further enhancement of the naturally occurring microorganisms using an injected carbon source, will reduce the remediation time of the plume compared to a natural attenuation approach.

The MNA approach appears to be a potential alternative because of the presence of TCE breakdown products across the plume; however, the rate of natural degradation can not be estimated because of a lack of historical groundwater data on the plume. Further data collection is needed to determine if this is a viable approach for the plume remediation.

The selected remedial approach is to use a combination of IRZ technology and MNA. IRZ technology will be implemented at the suspected source area and the off-site portion of the plume. MNA will be used for the bulk of the plume that is on the PCS Nitrogen property. As previously mentioned, there is insufficient data to fully justify a MNA approach and more data collection is required. A two-year monitoring program is proposed to evaluate the MNA parameters that are described in the EPA document "Technical Protocol For Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water" (EPA 1998). During this two-year monitoring program, groundwater quality data will collected and evaluated to achieve the following objectives:

- Confirm/deny that natural attenuation processes are occurring;
- Determine if the plume is stable, expanding, or shrinking; and
- Estimate the degradation rate of the TCE and breakdown products to estimate the plume remediation timeframe.

The potential disadvantage to performing two years of monitoring and not initiating active remediation, is that the plume could be expanding and continuing further off-site. Also, if there are significant amounts of TCE in the clayey-silt soils in the source area, this may act as continuing source of TCE to the deep surficial aquifer and concentrations may increase over time.

These disadvantages are proposed to be controlled by using active remediation, the IRZ technology, to treat the source area and the downgradient area. This will decrease concentrations in the source area and prevent further migration of the plume off-site.

3.3 Related Experience with the IRZ™ Technology

The IRZ ™ technology has been developed and patented by ARCADIS G&M and used at many locations across the country. The IRZ™ technology will allow for complete compound destruction of VOCs by supplying a supplemental carbon source of diluted molasses. A diluted molasses injection solution is desirable as a primary carbon source because it is non-toxic, food grade, and readily soluble in water; produces significant amounts of biomass on a pounds-yielded per pound-applied basis; and has been proven to be a successful primary carbon source in other applications. Various studies have been conducted that demonstrate that if the indigenous microorganisms are stimulated and anaerobic conditions are provided, chlorinated VOCs can be effectively transformed to innocuous compounds.

The chemical reactions induced by injection of a diluted volume of this material are no different than naturally occurring biodegradation processes. The molasses solution simply expedites the rate of the natural degradation reactions, and is entirely consumed during the reactions, leaving no residuals. The by-products of reductive dechlorination, i.e., the natural degradation process enhanced by IRZ™, are chloride ions, carbon dioxide, and water. Brief summaries of some of these sites are included in this section.

3.3.1 Avco-Lycoming Superfund Site, Pennsylvania

The patented process was first proposed as an alternative to an EPA-approved Record of Decision (ROD) for a pump and treat system to mitigate groundwater impacts. The primary constituent of concern was chromium, but chlorinated VOCs were also present. A successful short-term pilot test proved the technology to be immediately effective for the chromium impacts (Denis and Suthersan, 1998). Upon full-scale implementation, the data have also revealed the technology as effective in mitigating groundwater impacts from chlorinated VOCs (Nyer et al, 1998; Burdick and Jacobs, 1998). Full-scale implementation at this site involves an automated feed system to multiple injection points completed within approximately 25 feet of a silty sand overburden unit. Since startup in January 1997, the molasses injections (dilution rate ranging between 50:1 and 200:1) have increased the effective area exhibiting anaerobic conditions from localized areas (total less than 2,000 square feet) to an enlarged area of more than 20,000 square feet. As compared to pre-startup conditions, the enhanced reducing environment is characterized by reduced redox conditions (-100 mV and lower), increased sulfide, and increased total organic carbon. Total chlorinated VOCs in one "hot spot" monitoring well have been reduced from approximately 1 part per million (ppm) to under 100 parts per billion (ppb) (90 percent reduction). Concentrations in former pumping wells at the downgradient edge of the plume have been reduced from the 100 to 200 ppb range to non-detect.

3.3.2 State-Led Waste Site, California

The technology was proposed to mitigate groundwater impacts from chromium and chlorinated VOCs (TCE concentrations up to 17 ppm) at a former plating facility. A six-month pilot study showed the technology to be immediately effective for chromium within two months, with demonstrated reductions in chlorinated VOCs indicated in the latter part of the pilot test. Full-scale implementation involved the installation of more than 90 injection points to a depth of 25 feet using direct-push installation techniques.

Approximately 150 gallons of molasses solution was injected into each point in April 1997 and February 1998. The solution was mixed in a portable tank and introduced with the aid of a small pump. Periodic groundwater-quality data collected during 1997 and 1998 showed dramatically reduced chlorinated VOC and chromium concentrations in on-site wells. One on-site monitoring well within approximately 20 feet of an injection point had a TCE concentration of 4 ppm prior to injection, which decreased to under 2 ppb after the two injection events. Daughter products (1,2-DCE and VC) initially increased, but then also developed decreasing trends.

Another on-site well within 10 feet of an injection point had a TCE concentration of 17 ppm, which reduced to 1.5 ppm after the two injection events, and had similar trends in daughter products. Another trend noted in the data was a "spike" in concentrations following the first injection event in February 1998. Factors causing this result are thought to be an increased height of the water table and a "surfactant effect" as the injection solution diffused into the aquifer material and released additional absorbed organics.

3.3.3 Saegertown Industrial Area Superfund Site, Ohio

The technology was proposed to mitigate chromium and chlorinated VOC impacts to groundwater at a chemical manufacturing facility that were affecting an adjoining waterway and nearby private potable wells. The EPA approved an eight-month pilot study involving molasses injections (dilution rate ranging between 25:1 to 50:1) at several pre-existing monitoring wells and an aquifer test well completed in low permeability alluvium. A total of 34 injection events were completed between February and October 1998. The solution was mixed in a potable tank and introduced with the aid of a small pump. Review of biogeochemical parameters demonstrated enhanced reducing conditions characterized by reduced redox conditions (-200 mV and lower), increased concentrations of dissolved iron, dissolved manganese, carbon dioxide and ethene and ethane. Total VOCs in one well in the central part of the plume decreased from a 1997 average concentration of more than 2.3 ppm to less than 64 ppb, including a decrease in PCE from 1.7 ppm to 3 ppb. A nearby well indicated PCE concentrations decreasing from 210 ppb to 3 ppb.

3.3.4 State-Led Waste Site, Pennsylvania

A pump and treat system operated at the site for approximately 15 years to mitigate chromium and chlorinated VOC impacts in a shallow carbonate aquifer. Data indicated little mass removal (asymptotic conditions) in recent years. Molasses

solution was injected into source area wells during weekly events at a 50:1 dilution rate. An enhanced anaerobic zone was created, as evidenced by reduced redox readings (down to -390 mV), increased sulfide, increased carbon dioxide, and detectable ethene and ethane. TCE concentrations (approximately 200 ppb at initiation of molasses injections) were reduced by approximately 60 percent in two months and by 84 percent in four months. This project is significant in demonstrating that the diffusion controlled remedial effects of molasses injection are an effective alternative to the "flushing" action of traditional pump-and-treat scenarios.

4. Remedial Design

The remediation approach to the site includes a two-year monitoring program to assess natural attenuation that appears to be occurring within the plume and to assess the performance of the active remediation in the source area and the downgradient area . The active remediation will include implementation of the IRZ technology, which involves the injection of a carbon source into the aquifer to enhance or accelerate the natural biodegradation of chlorinated VOCs. The specific details for the monitoring plan and the IRZ plan are provided below.

4.1 Groundwater Monitoring Plan

The objective of the groundwater monitoring plan is to provide data for the following reasons:

- To confirm/deny that natural attenuation processes are occurring by collecting data and using the EPA MNA evaluation method;
- To determine if the plume is stable, expanding, or shrinking;
- To estimate the degradation rate of the TCE and breakdown products needed to estimate the plume remediation timeframe;
- To assess the performance of the IRZ remediation in the source area and downgradient area; and
- To evaluate the potentiometric surface of the deep surficial aquifer to better understand fluctuations in the groundwater flow direction.

Groundwater data will be collected over a two-year period. Monitoring will consist of a baseline monitoring event, two annual events, and quarterly events, which are summarized in Table 2. The baseline event will include the same data collection as the annual sampling events. Together with the RFI Phase III groundwater data, there will be four sets of chlorinated VOC data across the plume over a time period of more than three years. Groundwater data collection will be discussed in this section and the IRZ performance monitoring will be discussed in Section 4.3.5.

The wells to be used for the monitoring network include three on-site existing deep surficial wells, one off-site existing deep surficial monitor well, one new direct push well, and 12 existing direct push wells that were installed during the RFI Phase III work. By using these wells, a direct comparison can be made between the Phase III RFI data collected in June 2000 and the new data.

During the quarterly sampling event, 11 wells are included. Of these wells, five wells are outside of the plume and will be used to monitor potential expansion of the plume; AA on the east side of plume, W on the north side of plume, DSM-U22D on the southwest side of plume, and ARC-U1D and ARC-U2D on the south side of plume. Six other wells are within the plume and generally provide coverage across the plume. As presented in Table 2, there are two different parameter lists used for the sampling events. List #1 includes the COC compounds with two other compounds (discussed below). List #2 includes the biogeochemistry parameters that are described in the EPA document "Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater (EPA 1998). Groundwater samples will be analyzed for the list #1 parameters as indicated in Table 2. In addition, wells PCS-1 (new well near well P) and well P, will be analyzed for both list #1 and #2 parameters.

During the annual event, 17 wells will be sampled. Of these, five wells are within or nearby the shallow surficial, 12 wells are within the plume or within 100 feet of plume in the deep surficial aquifer. Table 2 indicates the parameter list for each well. Generally, a higher number of wells across the shallow and deep surficial aquifer will be sampled for list #1 parameters and a more select list will be sampled for list #2 parameters.

The groundwater will be analyzed for the site COCs using EPA Method 8260 and will include TCE, 1,1,1-trichloroethane, cis-1,2-dichloroethene, 1,1-dichloroethene, 1,1-dichloroethane, and vinyl chloride. Two additional compounds, trans-1,2-dichloroethene and chloroethane, will be analyzed because they are additional chlorinated VOC breakdown products not included on the COC.

In addition to groundwater sampling, a complete round of ground water level measurements will be collected from the all wells listed on Table 3. This information will be used to generate potentiometric surface maps for the shallow and deep surficial aquifer.

4.2 IRZ Technology Implementation

The IRZ technology will be applied in the source area and the downgradient area to remediate the off-site areas. The source area will have four molasses injection wells and the downgradient area will have nine injection wells that will be located along the west and/or south boundary of the PCS Nitrogen site.

The process used in both areas will be similar, direct push points will be installed to verify local lithology, injection points will be installed via direct push rig, a diluted molasses solution will injected into the aquifer, and groundwater in the injection wells and select downgradient monitoring well will be monitored on a periodic basis. Each of these areas is discussed below.

4.2.1 Verify Lithology in IRZ Injection Areas

A direct push well will be installed approximately 20-30 feet southwest of direct push well P, (as shown in Figure 6) to confirm local lit logy and will be used to monitor the molasses injection at wells P (shallow) and P (deep). The new well will be screened throughout the deep surfical aquifer (estimated to be 18-38 feet bls).

A direct push rig will be used to characterize the geology in the downgradient area, as shown on Figure 6. The lithology information will be used to establish the depths of the screen intervals for the injection points to be installed in this area.

4.2.2 Installation of Injection Points

At this time, we anticipate that the wells will be located in the source area and the down gradient area as shown on Figure 6. However, the locations of the injection wells will be established following the baseline-monitoring event. Updated water quality data and groundwater flow direction data will be used to most effectively locate the IRZ injection wells in the down gradient area.

For the source area, existing direct push wells P (shallow), P (deep), Q (shallow), and Q (deep) will be used for injection in this area. The P (shallow) and Q (shallow) wells are

¾" diameter PVC well screen (#10 slot) with a screened interval of 8-13 feet bls. The P (deep) and Q (deep) wells are ¾" diameter PVC well screen with a screened interval of 29-39 feet bls.

For the downgradient area, nine injection wells will be installed using a direct push rig, as performed in the RFI Phase III work. The wells will be constructed of l-inch-diameter PVC well casing and screen (#10 slot). Figure 7 shows the construction details for the injection wells. Generally the injection wells will be installed on a 40-foot spacing and the screen interval will be throughout the deep surficial aquifer, approximately 18-38 feet bls. This spacing has been used at other ARCADIS G&M sites in similar aquifer conditions.

4.2.3 Injection Solution

The injection solution will consist of blackstrap molasses and potable water. Blackstrap molasses contains sucrose, reducing sugars, ash, organic non-sugars, and water. Molasses is desirable as a primary carbon source because it is non-toxic, food grade, and readily soluble in water, and produces a significant amount of biomass on a pounds-yielded per pound-applied basis. The density of the raw molasses is approximately 11.7 pounds per gallon. The total consumable carbohydrate concentration in the molasses is approximately 72 percent by weight, or approximately 8.4 pounds per gallon. The initial molasses concentration will be 5%, but may vary depending on organic carbon concentrations and the redox conditions measured during groundwater monitoring activities addressed in the next section. A buffering agent, such as orthophosphates, may be used to maintain pH conditions conducive to biological activity.

The Georgia Underground Injection Control (UIC) rules require that the injection solution not exceed primary drinking water standards. Analysis of this injection solution mixture on other ARCADIS G&M projects in Georgia indicated that the primary drinking water standards were not exceeded.

4.2.4 Delivery System

The molasses solution will be added to the aquifer during the two-year monitoring period. The equipment will include a tank placed on a truck or trailer with an installed mixer necessary to thoroughly dilute and mix the molasses solution. The tank will be filled with water from a potable water source and the molasses will be added to achieve a 5% molasses solution. The molasses solution will be pumped from the mix tank to

the injection well using a centrifugal pump. The solution will be pumped into the aquifer under low pressure, 2-5 psi. The initial volumes of solution pumped into each injection well will be approximately 100 gallons, which equates to 5 gallons of 100% molasses.

4.2.5 Molasses Solution Injection Frequency and Monitoring

The schedule for the molasses injections is expected to be weekly for the first month, monthly for the first quarter, and quarterly thereafter. The first molasses solution injection dosage will be set at 100 gallons of a 5% molasses solution as discussed above. However, the frequency and dosage of the injections is highly dependant upon conditions within the aquifer. Careful monitoring of the injection wells is necessary to prevent under dosing or over dosing of the molasses. Ideally, the correct molasses dosage will change the aquifer to a reducing environment as fast as possible, thus increasing the rate of reductive chlorination. Under dosing will not have any deleterious affects, but the conditions for reductive chlorination will not be optimized. Overdosing could have two negative affects; the pH could drop low enough to stop or hinder any biological degradation, and/or methane gas can be produced. ARCADIS G&M experience has indicated that three critical parameters should be monitored to evaluate the injection dosage and frequency, they are, pH, oxidation/reduction potential (ORP), and total organic carbon (TOC).

The values for these parameters in an ideal, over dose, and under dose situation are presented as follows:

Parameter	Ideal	Overdosage	Underdosage
PH	6-8	< 6	NA
Oxidation/Reduction Potential (ORP)	Generally negative	NA	> -100 mV
Total Organic Carbon	50 - 100 mg/L	>500 mg/L	< 50 mg/L

NA = Not Applicable

Generally, pH should be in the neutral range and, as mentioned above, and will drop with the overdose of molasses. ORP is an indicator that a reducing environment is being achieved, which is necessary for reductive chlorination. TOC is an indicator of

the amount of the food source available to the microorganisms. Based on experience at other sites, the diluted molasses solution is intended to provide enough supplemental organic substrate so that the TOC content in the aquifer is 50 times the concentration of the chlorinated VOCs. Based on the maximum TCE concentration of approximately 2 mg/L, the target TOC concentration should be approximately 100 mg/L. This elevated organic carbon content should be maintained as the groundwater migrates through each reactive zone in the aquifer.

The pH and ORP parameters can be measured in the field and samples will be collected for TOC analysis at a laboratory. A summary of the IRZ performance monitoring is presented in Table 4.

For each of the scheduled visits, as mentioned above, the three parameters will be tested at each injection well and the monitor well for each area. The data will be evaluated in the field and the molasses dosage will be adjusted. A well down gradient from the two injection areas will be selected to identify the movement and affect of the molasses injection. For the source area, a new direct push well will be installed approximately 20-30 feet southwest of the direct push P well. This well will be screened across the deep surficial aquifer (20-38 feet bls). For the down gradient area, direct push well BB will be used for monitoring. This well will be approximately 20-30 feet down gradient of the line of injection wells.

4.2.6 Expectation of the IRZ Technology

At other sites where ARCADIS G&M has implemented IRZ, it was observed that there was a three to six month lag before changes in groundwater at monitor wells were observed. It does take time for the molasses to be distributed in the aquifer and initiate growth of the microorganisms. Also observed is an increase in chlorinated VOC concentrations during the initial phases of injections (three to six month period). This observation is due to the production of biological surfactants that act to desorb the chlorinated VOCs from the soil. This trend is short-lived, generally lasting three to six months. Once the reducing environment is established, chlorinated VOC concentrations decline. This decline is expected to occur in nine to twelve months following the first injection of molasses. Specific site conditions can change these general observations, however; the important point is that this is not a quick reaction and positive results may not be observed until a year or more after start-up.

4.2.7 Injection Permitting

The Georgia EPD rules relating to UIC require that an Underground Injection Permit be issued for injection of substances into the subsurface. ARCADIS G&M has secured injection permits for other sites in Georgia using the same 5% molasses solution. The UIC coordinator has indicated that injection of the molasses solution is acceptable provided that primary drinking water maximum contaminant levels (MCLs) are not exceeded. Following approval of this CAP, a permit application will be submitted.

5. Reporting

PCS Nitrogen will submit quarterly reports to Georgia EPD for the corrective action activities. The reports will include a description of activities, presentation of data collected, discussion of data, and activities to be completed during the next quarter. Groundwater level maps will be prepared for the shallow and deep surficial aquifer. The groundwater quality data will be summarized on tables and figures and laboratory analytical reports will be provided in the report appendices.

In the second annual report, a full discussion of the results from the two-year monitoring period will be presented. The discussion will include an evaluation of natural attenuation at this site, estimation of the plume remediation time using a MNA approach, evaluation of the IRZ performance, and recommendations for future remediation at the site.

6. Implementation Schedule

An implementation schedule is provided in a Gantt chart Figure 8. Following the approval of this CAP, arrangements will be made to conduct the first baseline groundwater sampling event. This baseline sampling event will start within 45 days of the CAP approval. Following this initial sampling round, the data will be evaluated and the design and work plans for the IRZ injection system and monitor wells will be completed. The IRZ system will be installed within 30 days of design/work plan completion. Initiation of molasses injections will occur following installations of injection wells. The frequency of molasses injections groundwater sampling events are shown on Figure 8.

Reports will be prepared as discussed in Section 5. As previously mentioned, the second annual report will provide a full discussion of the results of the two-year monitoring and IRZ program.

7. References

GA EPD, 1994, RCRA Facility Assessment, DSM Chemicals North America, Inc. August 1994; Georgia Department of Natural Resources, Environmental Protection Division, Hazardous Waste Management Branch, Atlanta, Georgia.

ARCADIS February 1998, RCRA Facility Investigation, PCS Nitrogen Fertilizer, L.P., February 1998; ARCADIS Geraghty & Miller Inc., Aiken, South Carolina.

ARCADIS November 1998, RCRA Facility Phase II Investigation, PCS Nitrogen Fertilizer, L.P., February 1998; ARCADIS Geraghty & Miller Inc., Aiken, South Carolina.

ARCADIS 2000, Phase III RCRA Facility Investigation Report Addendum, PCS Nitrogen Fertilizer, L.P., September 2000; ARCADIS Geraghty & Miller Inc., Tampa, Florida.

EPA 1998, Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Ground Water, U.S. Environmental Protection Agency, Office of Research and Development, EPA/600/R-98/128, September 1998.

Tables

SUMMARY OF CHLORINATED VOC DETECTIONS IN GROUNDWATER
PCS Nitrogen Fertilizer
Augusta, Georgia

Location Date Sampled	EPA MCL	J (Deep) 7/14/00	K (Deep) * 7/14/00	L (Deep) * 7/13/00	P (Deep) 7/19/00	P (Shallow) 7/19/00	Q (Deep) 7/19/00	Q (Shallow) 7/19/00	R (Deep) 7/21/00	T (Deep) 7/21/00	U (Deep) 7/21/00	V (Deep) 8/800	BB (Deep) 8/8/00	ARC-U1D 7/18/00	ARC-U2D 7/18/00
Volatile Organic Compounds (ug/L):															
Parent Compounds (Solvents)															
Trichloroethene	5	8	180	250	1200	2000	245	110	18	135	29	115	700	2200	4
1,1,1-trichloroethane	200	<2	<2	<2	<100	<2	8	<2	<2	<2	<2	<2	<2	<2	<2
Breakdown Products of Trichloroethene and 1,1,1-trichloroethane															
cis-1,2-dichloroethene	70	<2	27	25	600	255	36	9	12	12	<2	13	130	170	<2
Vinyl Chloride	2	<5	<5	9	<250	15	8	<5	<5	18	<5	<5	7	5	<5
1,1-dichloroethene	7	7	8	4	<100	6	29	7	4	11	8	48	32	18	4
1,1-dichloroethane	none	4	9	16	<100	<2	80	4	17	25	<2	13	20	<2	4
Other Compounds															
Benzene	5	<2	<2	<2	<100	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Chloroform	80	4	3	6	<100	<2	<2	<2	<2	<2	<2	<2	<2	<2	5
1,1,2-trichloroethane	5	<2	<2	<2	<100	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Total Xylenes	10,000	<5	<5	<5	<250	<2	<5	<5	<5	<5	<5	<5	<5	<5	<5

Footnotes:
This table contains data for the shallow and deep surficial aquifer wells that are associated with the plume originating near Direct Push Well P
USEPA MCL = United States Environmental Protection Agency Maximum Contaminant Level
* A duplicate sample was analyzed for this well location. The reported value is the higher value of the two analytical results.
[box] Concentration exceeds EPA MCL.
ug/L = micrograms per liter

TABLE 2
PROPOSED TWO-YEAR GROUNDWATER MONITORING PLAN
PCS Nitrogen Fertilizer
Augusta, Georgia

Well	Quarterly (List #)	Annual Parameters (List #)
New Well (PCS-1deep)*	1,2	1,2
DP K (shallow)	none	1
DP K (deep)	1	1
DP L (shallow)	none	1
DP R (shallow)	none	1
DP S (shallow)	none	1
DP S (deep)	none	1,2
DP T (shallow)	none	1
DP T (deep)	1	1,2
DP U (deep)	1	1
DP W (deep)	1	1
DP AA (deep)	1	1,2
DP BB (deep) **	1,2	1,2
DSM-U22D	1	1,2
ARC-U1D	1	1
ARC-U2D	1	1,2
ARC-U3D	1	1

* PCS-1 deep will be the IRZ source area monitor well, to be installed 20-30 feet southwest of DP P

** IRZ downgradient area monitor well

List #1 VOC Parameters	List #2 Biogeochemical Parameters
COCs for Site	
Trichloroethene	Alkalinity (mg/L as CaCO3)
1,1,1-trichloroethane	Carbon Dioxide
cis-1,2-dichloroethene	Chloride
1,1-dichloroethene	Ethane
1,1-dichloroethane	Ethene
Vinyl chloride	Iron (total, dissolved)
Chloroform	Methane
	Nitrate
Additional Compounds To Evaluate Biodegradation	Oxygen Reduction Potential (ORP)
trans-1,2-dichloroethene	Oxygen (dissolved- field)
Chloroethane	pH
	Sulfate (as SO4)
	Sulfide
	Temperature
	Total Organic Carbon

TABLE 3
GROUNDWATER LEVEL MONITORING WELLS
PCS Nitrogen Fertilizer
Augusta, Georgia

Groundwater Level Monitoring Wells	
A (shallow)	N (shallow)
A (deep)	O (shallow)
B (shallow)	P (shallow)
B (deep)	P (deep)
C (shallow)	Q (shallow)
C (deep)	Q (deep)
D (shallow)	R (shallow)
D (deep)	R (deep)
E (shallow)	S (shallow)
E (deep)	S (deep)
F (shallow)	T (shallow)
F (deep)	T (deep)
G (shallow)	U (shallow)
G (deep)	U (deep)
H (shallow)	V (deep)
H (deep)	W (deep)
I (shallow)	X (deep)
I (deep)	Y (deep)
J (shallow)	Z (deep)
J (deep)	AA (deep)
K (shallow)	BB (deep)
K (deep)	ARC-U1D
L (shallow)	ARC-U2D
L (deep)	ARC-U3D
M (shallow)	ARC-U4D

Groundwater level measurements will be recorded at all wells quarterly

TABLE 4
IRZ PERFORMANCE MONITORING SCHEDULE
PCS Nitrogen Fertilizer
Augusta, Georgia

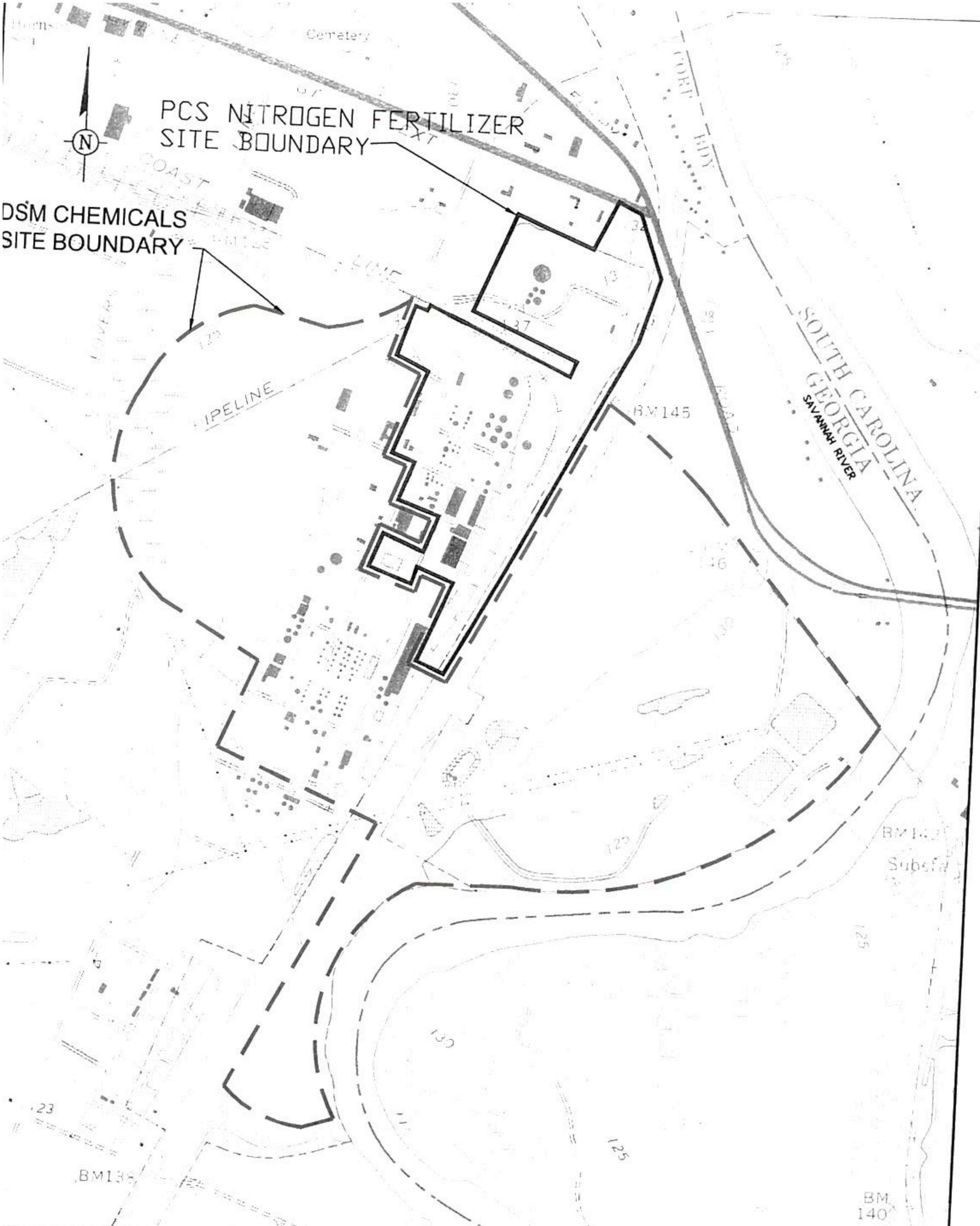
	Parameters
Source Area	
Injection Wells	
DP P (shallow)	pH, ORP, TOC
DP P (deep)	pH, ORP, TOC
DP Q (shallow)	pH, ORP, TOC
DP Q (deep)	pH, ORP, TOC
Monitor Well	
New Well PCS-1	pH, ORP, TOC
Downgradient Area	
Injection Wells	
I-1	pH, ORP, TOC
I-2	pH, ORP, TOC
I-3	pH, ORP, TOC
I-4	pH, ORP, TOC
I-5	pH, ORP, TOC
I-6	pH, ORP, TOC
I-7	pH, ORP, TOC
I-8	pH, ORP, TOC
I-9	pH, ORP, TOC
Monitor Well	
DP BB	pH, ORP, TOC

Note:
1. All wells will be analyzed for the above parameters prior to the injection of molasses solution.
2. The decision to inject molasses will be based on the table below.
3. The schedule for monitoring will be weekly for the first month, monthly for the first quarter, and quarterly thereafter.

Parameter	Ideal	Overdosage	Underdosage
PH	8-Jun	< 6	NA
Oxidation/Reduction Potential (ORP)	Generally negative	NA	> -100 mV
Total Organic Carbon	50 - 100 mg/L	>500 mg/L	< 50 mg/L

ARCADIS

Figures



RCADIS
3903 Northdale Boulevard, Suite 120
Tampa, Florida 33624
Tel: (813) 961-1921 Fax: (813) 264-3425

SITE LOCATION MAP

PCS NITROGEN FERTILIZER
AUGUSTA, GEORGIA

FIGURE

1

Georgia Department of Natural Resources
205 Butler Street, S.E., Suite 1162, Atlanta, Georgia 30334
Lonice C. Barrett, Commissioner
Environmental Protection Division
Harold F. Reheis, Director
404/656-2833

July 20, 2001

Mr. Virgil W. Fowler
Manager, Safety, Health and Environment
PCS Nitrogen Fertilizer, L.P.
P.O. Box 1483
Augusta, Georgia 30903

Re: Phase III RFI Report Addendum

Dear Mr. Fowler:

We have reviewed the Phase III RCRA Facility Investigation Report Addendum of September, 2000, submitted on behalf of PCS by ARCADIS Geraghty & Miller, Inc. The report is accepted.

As per condition II.F. of Corrective Action Order EPD –HW-1251, we request that you provide a Corrective Action Plan. The plan is due within 90 days.

Should you have any questions, contact K.Grall, B. Pierce or me at 404-656-2833.

Sincerely,

Dave Yardumian

Dave Yardumian
Unit Coordinator